Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE401	DESIGN OF STEEL STRUCTURES	4-0-0-4	2016

Prerequisite : CE202 Structural Analysis II

Course objectives:

- To introduce the limit state design of steel structural components subjected to bending, compression and tensile loads including the connections
- To enable design of structural components using timber

Syllabus:

Steel and steel structures – bolted and welded connections- tension members – compression members – beams – roof trusses – purlins – timber structures – columns- composite beams

Expected Outcomes:

The students will be able to

i. design bolted and welded connections
ii. design tension members and beams using the IS specifications
iii. design columns under axial loads using IS specifications
iv. design beams and plate girders
v. assess loads on truss and design purlins
vi. design structural components using timber.

Text Books:

1. L S Jayagopal, D Tensing., Design of steel structures, S Chand & Company, 2015
2. S K Duggal., Limit State design of steel structures, Tata McGraw Hill, 2010
3. Subramanian N, Design of steel Structures, Oxford University Press, 2011

References :

1. P. Dayaratnam., Design of Steel Structures ,Wheeler Publishing, 2003
2. Punmia B. C., Jain A. K. and Jain A. K., Design of Steel Structures, Laxmi Publications (P) Ltd, 2017
3. Raghupathi, Steel Structures, Tata McGraw Hill, 2006
4. Ramchandra S and Virendra Gehlot, Design of Steel Structures Vol. II, Standard Book House, 2007
5. V L Shah & Veena Gore, Limit State Design of steel Structures , Structures Publications, 2009
6. William T Segui., Steel Design , Cenage Learning, 6e, 2017
7. IS 800 – 2007, Code of practice for Structural steel design, BIS

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	Introduction to steel and steel structures, properties of steel, structural steel sections. Introduction to design: Design loads and load combinations, limit state design concepts. Connections bolted and welded (direct loads)	9	15

II	Tension members-Types of sections – net area- design of tension members- concept of shear lag-use of lug angle-connections in tension members	9	15
FIRST INTERNAL EXAMINATION			
III	Compression members- design of struts- solid and built up columns for axial loads-- design of lacings and battens-column bases- slab base – gusseted base	10	15
IV	Design of beams- laterally restrained and unrestrained – simple and compound beams- plate girders subjected to uniformly distributed loads – design of stiffeners.	9	15
SECOND INTERNAL EXAMINATION			
V	Design of roof trusses- types-design loads and load combinations-assessment of wind loads- design of purlins. Moment resistant/Eccentric connections (in plane and out of plane)	10	20
VI	Design of timber structures: types of timber - classification - allowable stresses-design of beams-flexure, shear, bearing and deflection considerations-Design of columns. Design of composite beam sections with timber and steel.	9	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks : 100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1. Each part should have at least one question from each module

2 .Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE403	STRUCTURL ANALYSIS - III	3-0-0-3	2016

Prerequisite :CE303 Structural Analysis - II

Course objectives:

- To enable the students to have a comprehensive idea of matrix structural analysis with emphasis on the relative advantages of the flexibility method and the stiffness method
- To enable the students to visualize structural dynamics problems with a proper blend of structural analysis and vibration theory

Syllabus :

Approximate Methods of Analysis of Multistoried Frames, Matrix analysis of structures, Flexibility method, Stiffness method, Introduction to direct stiffness method, Structural dynamics

Expected Outcomes:

The students will be able to

i. analyse structures using approximate method
ii. analyse trusses, continuous beams and rigid frames using flexibility method
iii. analyse trusses, continuous beams and rigid frames by stiffness method
iv. conceive Finite element procedures by direct stiffness method
v. use the basics of structural dynamics and analyse the response of SDOF systems

Text Books :

1. G S Pandit and S P Gupta, Structural analysis a Matrix approach, McGraw Hill Education (India), 2e, 2008
2. Gere, J.M. and William Weaver, Matrix Analysis of framed structures, CBS Publishers, 1990
3. Kenneth M Leet, Chia Ming Uang, Anne M Gilbert, Fundamentals of structural analysis, Tata McGraw Hill Pvt Ltd., 4e, 2010
4. Reddy C.S., Basic structural analysis, Tata McGraw Hill, third edition, 3e, 2012

References :

1. Anil. K. Chopra, Dynamics of structures, Pearson Education/ Prentice Hall India, 5e, 2016
2. Clough R.W. and Penzein, J., Dynamics of structures, Tata McGraw Hill, 1995
3. Madhujith Mukhopadhyay and Abdul Hamid Sheikh, Matrix and Finite Element Analysis of Structures, Ane Books India, 2009
4. Mario Paz , Structural Dynamics: Theory & Computation, 2e, CBS Publishers, 2004
5. Rajasekharan. S. and Sankarasubramanian G., Computational structural Mechanics, PHI, 2009
6. Wang C.K., Matrix method of structural analysis, International Text book company, 1970

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	Approximate Methods of Analysis of Multistoried Frames: Analysis for vertical loads-substitute frames-loading condition for maximum hogging and sagging moments in beams and maximum bending moment in columns- wind load analysis of multistoried frames – portal method and cantilever method for lateral load analysis.	6	15

II	Matrix analysis of structures: static and kinematic indeterminacy-force and displacement method of analysis-definition of flexibility and stiffness influence coefficients Concepts of physical approach	6	15
FIRST INTERNAL EXAMINATION			
III	Flexibility method: flexibility matrices for truss and frame elements-load transformation matrix-development of total flexibility matrix of the structure-analysis of simple structures-plane truss and plane frame-nodal loads and element loads-lack of fit and temperature effects	7	15
IV	Stiffness method: Development of stiffness matrices by physical approach-stiffness matrices for truss and frame elements-displacement transformation matrix-analysis of simple structures-plane truss and plane frame-nodal loads and element loads-lack of fit and temperature effects	7	15
SECOND INTERNAL EXAMINATION			
V	Introduction to direct stiffness method-Rotation of axes in two dimensions, stiffness matrix of elements in global co- ordinates from element co-ordinates- assembly of load vector and stiffness matrix, solution of two span continuous beam-single bay single storey portal frame.	8	20
VI	Structural dynamics-introduction-degrees of freedom-single degree of freedom subjected to harmonic load -linear systems- equation of motion, D'Alembert's principle-damping- free response of damped and undamped systems- logarithmic decrement- transient and steady state responses, Dynamic magnification factor – Vibration isolation –Concept of two degree of freedom systems (No derivation and numerical problems)	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2. Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE405	ENVIRONMENTAL ENGINEERING- I	3-0-0-3	2016

Pre-requisites: CE203 Fluid Mechanics -I

Course objectives:`

- To study the significance of water resources and the factors affecting the quality and quantity of water
- To study the various types of treatment techniques adopted for a public water supply system

Syllabus :

Water sources, demand, factors, Quantity estimation, Population forecasting, Quality of water. Water treatment- Physical methods, Chemical methods. Design of sedimentation tank, flocculator, clariflocculator, filters, Membrane treatment techniques. Disinfection- methods. Distribution of water, Pumps, Hardy Cross method of analysis

Expected Outcomes:

The students will

i. become aware of the various pollutants affecting water quality

ii. know about the different treatment units available in a water treatment plant and their design procedures

Text Books:

1. B.C Punmia, "Water Supply Engineering", Laxmi Publications Pvt. Ltd., 2016
2. G S Birdie, Water Supply and Engineering, Dhanapat Rai Publishing Company, 2014
3. P.N. Modi, "Water Supply Engineering", Standard Book House, NewDelhi
4. Peavy H S, Rowe, D.R. Tchobanaglous "Environmental Engineering" Mc GrawHill Education, 1984
5. S.K.Garg, "Water Supply Engineering", Khanna Publishers. 2010

References

1. K N Dugal, Elements of Environmental Engineering, S Chand and Company Pvt Ltd, 2007
2. Mackenzie L Davis, Introduction to Environmental Engineering, McGrawhill Education (India), 2012
3. Metcalf & Eddy , "Waste Water Engineering", Tata Mc Grawhill Publishing Co Ltd, 2003
4. P Venugopala Rao, Environmental Engineering, PHI Learning Pvt Ltd, 2002
5. Subhash Verma, Varinder Kanwar, Siby John, Water supply Engineering, Vikash Publishing, 2015

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	Introduction of environment- sources of water supply-Water demand, quantification of water demand through population forecasting – Factors affecting consumption-Fluctuations in demand	7	15

II	Types of intakes-Conveyors, pumps and location of pumping station-Quality of water - Drinking water standards - Physical, chemical and biological analysis.	6	15
FIRST INTERNAL EXAMINATION			
III	Treatment of water-Theory and principles of Sedimentation tanks-Stoke's law-Types of settling (Type I & Type II only)-Coagulation-Mixing-Flocculation, Design of Sedimentation tanks (circular and rectangular)-Clariflocculators	7	15
IV	Filtration-Types of filters- Working and Design of Rapid and Slow sand filters. Loss of head in filters, Pressure filters	7	15
SECOND INTERNAL EXAMINATION			
V	Disinfection of water - Methods, Chlorination-Types, Factors affecting - Chlorine demands. Miscellaneous treatment-Ion exchange, Lime-soda process, Electro dialysis - Colour, Taste and Odour removal-Adsorption-Aeration-Fluoridation-Defluoridation	7	20
VI	Lay out of water distribution network-Methods of distribution-Hardy cross method-Equivalent pipe method-Pipe appurtenances.	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note :

1. Each part should have at least one question from each module
2. Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE407	TRANSPORTATION ENGINEERING - II	3-0-0-3	2016

Prerequisite : CE308 Transportation Engg.-I

Course Objectives:

- To set a solid and firm foundation in Railway engineering, including the history development, modern trends, maintenance, geometric design and safety of railways.
- To introduce dock, harbour and tunneling

Syllabus :

Introduction to railways in India and its evolution, modern technologies, geometric design of tracks, railway operation control, maintenance and an introduction to the railway accidents. Alignment, surveying, driving, ventilation and drainage of tunnels and types of harbours and docks.

Course Outcome:

- This course will enable students to gain knowledge in railway and water transportation.

Text Books:

1. Mundrey J. S, Railway Track Engineering, Tata McGraw Hill, 2009
2. Rangawala, S.C. , Railway Engineering, Charotor Publishing House
3. Rao G. V, Principles of Transportation and Highway Engineering, Tata McGrawHill, 1996
4. Srinivasan,R., Harbour, Dock & Tunnel Engineering, Charotor Publishing House, 28e, 2016

References:

1. Bindra, S.P., A course in Docks and Harbour Engineering, Dhanpat Rai& Sons
2. Chandra, S. and Agarwal, M.M. ,Railway Engineering, Oxford University Press, New Delhi, 2008
3. Saxena, S. C and Arora, S. P, Railway Engineering, Dhanpat Rai& Sons, 7e, 2010
4. Subhash C. Saxena, Railway Engineering, Dhanpat Rai& Sons

Module	Contents	Hours	Sem. Exam Marks %
I	**Introduction to Railways in India**: Role of Indian Railways in National Development – Railways for Urban Transportation – Modern developments- LRT & MRTS, tube railways, high speed tracks. Alignment- basic requirements and factors affecting selection, Component parts of a railway track - requirements and functions - Typical cross-section	7	15
II	**Permanent Way**: Components and their Functions: Rails - Types of Rails, Rail Fastenings, Concept of Gauges, Coning of Wheels, Creeps and kinks . Sleepers – Functions, Materials, Density , Ballast less Tracks. Geometric design of railway track: Horizontal curves, radius – super	7	15

	elevation -cant deficiency - transition curves - gradients - different types - Compensation of gradients.		
FIRST INTERNAL EXAMINATION			
III	**Railway operation and control:** Points and Crossings – Design features of a turnout – Details of station yards and marshalling yards – Signaling, interlocking of signals and points - Principles of track circuiting - Control systems of train movements – ATC, CTC – track circuiting	**6**	**15**
IV	**Maintenance**:- Introduction to track maintenance, Items of track maintenance, packing and over hauling, screening **Railway accidents:** Human and system contribution to catastrophic accidents, Human Factors in Transport Safety.	**6**	**15**
SECOND INTERNAL EXAMINATION			
V	**Tunnel Engineering: Tunnel** - sections - classification - tunnel surveying -alignment, transferring centre, grade into tunnel – tunnel driving procedure - shield method of tunneling, compressed air method, tunnel boring machine, Tunnel lining, ventilation - lighting and drainage of tunnels.	**8**	**20**
VI	**Harbours**– classification, features, requirements, winds and waves in the location and design of harbours. **Break waters** - necessity and functions, classification, alignment, design principles, forces acting on break water – construction, general study of quays, piers, wharves, jetties, transit sheds and warehouses - navigational aids - light houses, signals - types - Moorings **Docks** – Functions and types - dry docks, wet docks – form and arrangement of basins and docks	**8**	**20**
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2 Each question can have a maximum of 4 subdivisions (a,b,c,d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE409	QUANTITY SURVEYING AND VALUATION	3-0-0-3	2016

Pre-requisites: CE334 Computer Aided Civil Engg. Lab

Course objectives:

- To have an awareness regarding specifications, analysis of rates, valuation etc. in connection with construction
- To prepare detailed estimates, bar bending schedules of various items of work

Syllabus :

Specifications- Analysis of rates- CPWD data book and schedule of rates- Detailed specification, preparation of data and analysis of rates for various items of work- Quantity Surveying- Types of Estimate - Valuation- Methods of valuation-Depreciation- Fixation of rent- Detailed estimate including quantities, abstract and preparation of various items of works, Preparation of bar bending schedules for various RCC works

Expected Outcomes:

The students will be able to

i. work out the quantities of materials and labour required for different types of civil works
ii. prepare schedule of rates for various items of work

Text Books

1. B N Dutta, Estimating and costing in Civil Engineering, USB publishers and distributers Ltd. New Delhi
2. D D Kohli, RC Kohli, A textbook of Estimating and costing, S Chand Publishing, 2011
3. Dr. S. Seetharaman, M. Chinnasamy, Estimation and Quantity Surveying, Anuradha Publications , Chennai.

References:

1. BS Patil, Civil Engineering contracts and estimates, Universities press
2. V N Vazirani & S P Chandola, Civil engineering Estimating and Costing, Khanna Publishers.
3. IS 1200-1968; Methods of measurement of Building & Civil Engineering works.
4. CPWD data book and schedule of rates.

Note:

For analysis of rate and cost estimation, unit rate and labour requirement should be given along with the questions in the question paper.. No other charts, tables, codes are permitted in the Examination Hall. If necessary, relevant data shall be given along with the question paper.

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	General Introduction- Quantity Surveying- Basic principles-Types of Estimates - Specifications- purposes and basic principles-general specifications - Detailed specifications-Method of measurement of various items of work. Analysis of rates- Introduction to the use of CPWD data book and schedule of rates- conveyance and conveyance statement -	6	10

	Miscellaneous charges.		
II	Preparation of data and analysis of rates for various items of work connected with building construction and other civil engineering structures with reference to Indian Standard Specification.	6	10
FIRST INTERNAL EXAMINATION			
III	Detailed estimate including quantities, abstract and preparation of various items of works- buildings- centerline method and long wall short wall method- sanitary and water supply works- soak pits, septic tanks, overhead tanks, culverts, Retaining walls, road construction. Bar-bending schedule-preparation of bar-bending schedule for RCC works connected with building construction, culverts and minor irrigation works.	18	50
SECOND INTERNAL EXAMINATION			
IV	Valuation - Explanation of terms, types of values, sinking fund, years purchase, Depreciation - Straight line method, constant percentage method, S.F method .Obsolescence. Valuation of real properties-rental method, profit based method, depreciation method. Valuation of landed properties -belting method, development method, hypothecated building scheme method. Rent calculation. Lease and Lease hold property	12	30
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks: 100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 10 marks each

Part B - Module III : 2 questions out of 3 questions carrying 25 marks each

Part C - Module IV : 2 questions out of 3 questions carrying 15 marks each

Note : 1. Part A should have at least one question from each module

2. Part B three full questions carrying 25 marks on building estimate, preparation of bending schedule, or estimation of any other structure.

3. Part A and C each question can have a maximum of 2 subdivisions (a, b)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE461	WAVE HYDRODYNAMICS AND CAOSTAL ENGINEERING	3-0-0-3	2016

Pre-requisite : CE206 : Fluid Mechanics II

Course objectives:

1. To introduce the fundamentals in ocean wave mechanics and coastal engineering.
2. To impart knowledge and comprehension over the basic aspects of wave hydrodynamics.
3. To equip the students with the state-of-the-art in coastal zone protection.

Syllabus :

Linear Wave Theory-Derivation for Velocity potential, Wave kinematics, Wave kinetics, Wave Power. Wave propagation in Shallow water region. Wave pressure, Wave forces-Morrison equation, Froude –Krylov force, Linear diffraction theory. Coastal process, Coastal protection works, Environmental parameters.

Expected Outcomes:

- The students will be able to develop skills and knowledge to solve the issues connected with ocean wave interaction with offshore and coastal features.

Text Book :

Dominic Reeve, Andrew Chadwick, Chris Fleming. Coastal Engineering : Processes, Theory and Design Practice, CRC Press, 2015

References:

1. Narashimhan, S.and S. Kathiroli(Ed.), Harbour and Coastal Engineering(Indian Scenario), -NIOT Chennai, 2002
2. US Army Corps of Engineers, Coastal Engineering Manual, 2002
3. US Army Corps of Engineers, Shore Protection Manual, Coastal Engineering Research Centre, Washington, 1984.
4. V.Sundar, Ocean wave Mechanics Applications in Marine Structures, Ane Book Pvt Ltd, New Delhi, 2016.
5. William Kamphuis ; Introduction to Coastal Engineering and Management, World Scientific, 2002.

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	A brief overview on fundamental principles of fluid mechanics (No questions for examination). Characteristics of a regular ocean wave (Wave length, Wave period and wave celerity).Difference between regular and random waves, Linear Wave theory-Assumptions. Boundary Conditions-Kinematic free surface, Dynamic free	7	15

	surface. Separable solution of Laplace Equation for velocity potential. Dispersion equation derivation, Dispersion relationship in different water depth conditions (Shallow, intermediate and deep). Worked out exercises.		
II	Particle velocity and acceleration under wave transport. Particle Displacement. Orbital motion of water particles at different water depth. Derivation for potential energy and kinetic energy. Worked out exercises. Energy flux/Wave power, Derivation for group celerity.	7	15
FIRST INTERNAL EXAMINATION			
III	Wave propagation in shallow water- Wave shoaling –Derivation for shoaling coefficient- Worked out exercises. Wave refraction-analytical expression for refraction coefficient, Combined effect of shoaling and refraction-worked out exercises. Wave diffraction –its significance in harbor planning. Wave reflection-effect of surf similarity parameter. Wave breaking- in shallow water, Breaker types. Wave set up and set down, Wave run up.	6	15
IV	Pressure field under progressive wave, Pressure response factor, Dynamic pressure component. Wave force formulation, force regimes. Wave forces on slender circular members-Morrison Equation. Worked out exercises.	6	15
SECOND INTERNAL EXAMINATION			
V	Discussion on Wave Forces on large bodies, Froude –Krylov force-general theory. Diffraction theory-Linear diffraction problem-general theory and solution formulation. Wave forces on coastal structures-A brief overview on small amplitude wave theories – only at conceptual level. Wave force by Hirori Formula, Sainflou formula, Nagai Formula. Discussion only on Goda Formula.	8	20
VI	Introduction to beach and Coastal process-terms describing beach profile. Coastal erosion process-Natural and man made factors. Shallow water effects in coastal erosion. Long shore sediment transport and its effects on coastal process (only discussion). Near shore currents, cross shore sediment transport. Coastal protection (Only discussion, design is not expected)-important factors to be considered. Coastal protection methods-shore parallel and shore perpendicular structures, beach nourishment, Environmental parameters considered in design.	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
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2014

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE463	BRIDGE ENGINEERING	3-0-0-3	2016

Prerequisite: CE 301 Design of Concrete structures I

Course objectives:

- To impart knowledge on important types of bridge structures, their selection and planning, structural configurations, assessment of loads and perform design.

Syllabus :

General considerations for road bridges, Standard specifications for road bridges, Design of slab bridges and box culverts, T beam bridges, Prestressed concrete bridges, substructures, bearings, bridge foundations

Course Outcomes:

The students will be able to

i. use IRC standards and design the deck slab
ii. analyse, design and detail Box culverts for the given loading
iii. design and detail T-Beam bridges
iv. design and check the stability of piers and abutments
v. design bridge bearings
vi. detail bridge foundations and prepare the bar bending schedule

Text Books :

1. Jagadish T.R. & M.A. Jayaram, "Design of Bridge Structures",2nd Edition, 2009.
2. Johnson victor D, "Essentials of Bridge Engineering", 7th Edition, Oxford, IBH publishing Co.,Ltd, 2006
3. N.KrishnaRaju " Prestressed Concrete Bridges" CBS Publishers 2012

References:

1. Krishna Raju N., "Design of Bridges", 4th Edition, Oxford and IBH Publishing Co., Ltd., 2008
2. Ponnu Swamy, "Bridge Engineering", 4th Edition, McGraw-Hill Publication, 2008.
3. Swami Saran, "Analysis and Design of sub-structures",2nd Edition, Oxford IBH Publishing co ltd., 2006.
4. Vazirani, Ratvani & Aswani, "Design of Concrete Bridges",5th Edition, Khanna Publishers, 2006.

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	Introduction :Definition and Basic Forms, Component of bridge, classification of bridge, short history of bridge development, Site selection-Soil Exploration for site Importance of Hydraulic factors in Bridge Design. General arrangement drawing.	6	15

II	Standard specification for Road bridges : Width of carriageway- Clearances- Loads to be considered- Dead load – I.R.C. standard live loads- Impact effect – Wind load –Longitudinal forces- Centrifugal forces- Horizontal forces due to water currents – Buoyancy effect- Earth pressure.	6	15
FIRST INTERNAL EXAMINATION			
III	Solid slab bridges : Introduction, General design features, Effective width method. Simply supported and cantilever Slab Bridge, analysis and design. Box Culverts : Introduction to analysis, design and detailing, Loading conditions (detailed design not expected)	7	15
IV	Beam and slab bridges: Introduction, Design of interior panel of slab. Pigeaud's method, Calculation of longitudinal moment Courbon's theory, Design of longitudinal girder, design example. and Reinforcement detailing	7	15
SECOND INTERNAL EXAMINATION			
V	Introduction to pre-stressed concrete bridges (Design Concepts only) Determination of SMinimum Section Modulus, Prestressing Force and eccentricity (Derivation not required) Substructures : Analysis and Design of Abutments and pier- detailing.	8	20
VI	Bridge bearings: forces on bearings, design of elastomeric bearings, basics for selection of bearings. Types of foundations, well foundation–open well foundation, components of well foundation, pile foundations (designs not included) - detailing only	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (External Evaluation)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE465	GEO-ENVIRONMENTAL ENGINEERING	3-0-0-3	2016

Pre-requisite: CE 305 Geotechnical Engineering- II

Course objectives:

- To create a awareness in the field of Geo-Environmental Engineering
- To impart the knowledge on Geotechnical aspects in the disposal of waste materials and the remediation of contaminated sites
- To familiarise design of landfill and know the effect of change in environment on soil properties.

Syllabus :

Introduction and Soil-water-environment interaction, Geotechnical applications of waste materials, Geotechnical characterization of waste and disposal, Site characterization, Landfill Components its functions and design, Compacted clay liner, selection of soil, methodology of construction, Geosynthetics in landfill- types and functions, geosynthetic clay liners - Leachate and Gas Management, Soil remediation, Investigation of contaminated soil, insitu/exiture mediations, bio remediation, thermal remediation, pump and treat method, phyto remediation and electro kinetic remediation, Leachate disposal and Post closure of landfill, Variation in properties of soil due to change in environment

Expected Outcomes:

The students will be able to:

i. Deal with geoenvironmental engineering problems
ii. Utilize waste in Geotechnical applications
iii. Design Landfill
iv. Mange leachate and landfill gas
v. Do investigation on contaminated site and soil remediation
vi. Assess variation in engineering properties of soil due to change in environment

Text Books / References

1. Daniel, D.E. (1993). Geotechnical Practice for Waste Disposal. Chapman, and Hall, London.
2. Koerner, R.M. (2005). Designing with Geosynthetics. Fifth Edition. Prentice Hall, New Jersey.
3. Reddi L.N and Inyang HI (2000) Geoenvironmental Engineering: Principles and Applications, Marcel Dekker Inc Publication
4. R. N. Yong (2000) Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate, Mitigation Lewis Publication.
5. Dr. G V Rao and Dr. R S Sasidhar (2009) Solid waste Management and Engineered Landfills, Saimaster Geoenvironmental Services Pvt. Ltd. Publication.
6. Ayyar TSR (2000) Soil engineering in relation to environment, LBS centre for Science and Technology, Trivandrum.
7. Hari D. Sharma, Krishna R. Reddy (2004) Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, Publisher: John Wiley & Sons Inc.
8. Donald L. Wise, Debra J. Trantolo, Hilary I. Inyang, Edward J. Cichon (2000) Remediation Engineering of Contaminated Soils, Publisher: Marcel Dekker Inc.

COURSE PLAN			
Module	**Contents**	**Hours**	**Sem. Exam Marks %**
I	Introduction and Soil-water-environment interaction : Introduction to geoenvironmental Engineering, Soil-water-environment interaction relating to geotechnical problems, Waste:-source, classification and management of waste, Physical, chemical and geotechnical characterization of municipal solid waste, Impact of waste dump and its remediation	6	15
II	Geotechnical application of waste and disposal: Geotechnical use of different types such as Thermal power plant waste, MSW, mine waste, industrial waste. Waste disposal facilities, Parameters controlling the selection of site for sanitary and industrial landfill. Site characterization. MoEF guidelines.	7	15
FIRST INTERNAL EXAMINATION			
III	Landfill Components :Landfill layout and capacity, components of landfill and its functions. Types and functions of liner and cover systems, Compacted clay liner, selection of soil for liner, methodology of construction.	6	15
IV	**Leachate, Gas Management and Geosynthetics**: Management of Leachate and gas. Various components of leachate collection and removal system and its design., gas disposal/utilization. Closure and post closure monitoring system Geosynthetics- Geo membranes - geosynthetics clay liners -testing and design aspects.	6	15
SECOND INTERNAL EXAMINATION			
V	Soil remediation : Investigation of contaminated soil, sampling, assessment Transport of contaminants in saturated soil. Remediation of contaminated soil- in-situ / exit remediation, bio remediation, thermal remediation, pump and treat method, phyto remediation and electro-kinetic remediation	9	20
VI	Change in engineering properties due to change in environment. Variation in Engineering properties of soil –atterberg limit, shear strength, permeability and swelling due to change in environment/pore fluid.	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE467	HIGHWAY PAVEMENT DESIGN	3-0-0-3	2016

Pre-requisite : CE208 Geo Technical Engineering - I

Course Objectives:

- To introduce highway pavements, design concepts and material properties,
- To understand and enable students to carry out design of bituminous mixes, analyse and design flexible and rigid highway pavements
- To introduce the concepts of pavement evaluation and rehabilitation.

Syllabus :

Introduction to highway pavements – Subgrade soil properties – Design of bituminous mixes- Analysis of flexible pavements- Design of flexible pavements- Analysis of rigid pavements- Design of rigid pavements-Pavement evaluation- Introduction to design of pavement overlays.

Course Outcome:

The students will be able to

i. identify the pavement components and design bituminous mixes,
ii. analyze and design flexible and rigid pavements
iii. evaluate structural condition of pavement.

Text Books:

1. Yoder and Witezak, Principles of Pavement design, John Wiley and sons, second edition,1975.
2. Yang, Design of functional pavements, McGraw- Hill,1972.
3. Khanna S. K. & Justo C. E. G., Highway Engineering, Nemchand & Bros, 9e.
4. Hass & Hudson, 'Pavement Management System', McGraw Hill Book Co, 1978.

References:

1. IRC: 37 - 2001, 'Guidelines for the Design of Flexible Pavements'.
2. IRC: 58 – 2002, 'Guidelines for the Design of Rigid Pavements'.
3. IRC: 37-2012, 'Tentative Guidelines for the Design of Flexible Pavements'.
4. IRC: 58-2011, Guidelines for Design of Plain Jointed Rigid Pavements for Highways.

Module	Contents	Hours	Sem. Exam Marks %
I	Introduction to highway pavements, Types and component parts of pavements, Factors affecting design and performance of pavements, Functions and significance of sub grade properties, Various methods of assessment of sub grade soil strength for pavement design Mix design procedures in mechanical stabilization of soils,	6	15

	Design of bituminous mixes by Marshall, Hubbard - field and Hveem's methods		
II	Introduction to analysis and design of flexible pavements, Stresses and deflections in homogeneous masses, Burmister's 2 layer and 3 layer theories, Wheel load stresses, ESWL of multiple wheels, Repeated loads and EWL factors	**6**	**15**
FIRST INTERNAL EXAMINATION			
III	Empirical, semi - empirical and theoretical approaches for flexible pavement design, Group index, CBR, Triaxial, Mcleod and Burmister layered system methods	**7**	**15**
IV	Introduction to analysis and design of rigid pavements, Types of stresses and causes, Factors influencing stresses, General conditions in rigid pavement analysis, Warping stresses, Frictional stresses, Combined stresses	**7**	**15**
SECOND INTERNAL EXAMINATION			
V	Joints in cement concrete pavements, Joint spacings, Design of slab thickness, Design and detailing of longitudinal, contraction and expansion joints, IRC methods of Design	**8**	**20**
VI	Introduction to pavement evaluation, Structural and functional requirements of flexible and rigid pavements, Quality control tests for highway pavements, Evaluation of pavement structural condition by Benkelman beam, rebound deflection and plate load tests, Introduction to design of pavement overlays and the use of geosynthetics	**8**	**20**
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b ,c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE469	ENVIRONMENTAL IMPACT ASSESSMENT	3-0-0-3	2016

Prerequisites: Nil

Course objectives:

- To know the various types of environmental pollution
- To make aware the impact due to various types of pollutants and their assessment technique

Syllabus : Pollution, Types. Air pollution-sources, effects, types of pollutants. Water pollution, characteristics of water pollutants, Solid wastes, sources, types, soil pollution, pesticide pollution. Noise pollution, Impacts, positive and negative Environmental impact assessment, steps of doing EIA, methodology adopted, EIA procedure in India, Case studies.

Expected Outcomes:

- The students will gain basic knowledge of various pollution sources and their impacts

Text Books / References:

1. A K Srivastava, Environment impact Assessment, APH Publishing, 2014
2. John Glasson, Riki Therivel & S Andrew Chadwick "Introduction to EIA" University College London Press Limited, 2011
3. Larry W Canter, "Environmental Impact Assessment", McGraw Hill Inc. , New York, 1995.
4. Ministry of Environment & Forests, Govt. of India 2006 EIA Notification
5. Rau G J and Wooten C.D "EIA Analysis Hand Book" Mc Graw Hill
6. Robert A Corbett "Standard Handbook of Environmental Engineering" McGraw Hill, 1999.

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	INTRODUCTION: Classification of Pollution and Pollutants, – Evolution of EIA (Global and Indian Scenario)- Elements of EIA — Screening – Scoping - Public Consultation - Environmental Clearance process in India - Key Elements in 2006 EIA(Govt. of India) Notification	6	15
II	AIR POLLUTION: Primary and Secondary Types of Pollutants, sulfur dioxide- nitrogen dioxide, carbon monoxide, WATER POLLUTION: Point and Non-point Source of Pollution, Major Pollutants of Water, Impact of pollutants	6	15
	FIRST INTERNAL EXAMINATION		
III	SOLID WASTE: Classification and sources of Solid Waste, Characteristics, effects, e waste, : Effects of urbanization on land degradation, pesticide pollution NOISE POLLUTION: Sources of Noise, Effects of Noise,	7	15

	Control measures		
IV	Impacts of pollutants, types, scale of impact-Global, local pollutants. Climate change, Ozone layer depletion, Deforestation, land degradation , Impact of development on vegetation and wild life	7	15,
SECOND INTERNAL EXAMINATION			
V	Socio-economic impacts - Impact assessment Methodologies- Overlays, Checklist, Matrices, Fault Tree Analysis, Event Tree Analysis- Role of an Environmental Engineer- Public Participation	8	20
VI	Standards for Water, Air and Noise Quality - Environmental Management Plan- EIA- Case studies of EIA	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (External Evaluation) :

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE471	ADVANCED STRUCTURAL DESIGN	3-0-0-3	2016

Prerequisite : CE304 Design of Concrete Structures- II

Course objectives:

- To enable the students to assess the loads on some important types of structures, choose the method of appropriate analysis according to the situation and perform design
- To analyse and design the special structures in steel and understand the new concepts of design

Syllabus :

Design of deep beams, corbels, ribbed slabs, flat slabs, Yield line theory, Design of multi storey buildings, Design of Gantry girder, Design of Industrial structures, beam column connections, Analysis and design of light gauge structures ,Tall structures, Shear wall ductility detailing

Course Outcomes:

The students will be able to

i. design deep beams, corbels. Ribbed slabs
ii. design and detail a flat slab and multistory buildings
iii. analyse and design light gauge structures
iv. calculate the loads on gantry girder and its design
v. design beam column Connections
vi. analyse, design and detail multistory building for lateral loads

Text Books / References:

1. Krishnaraju.N., Advanced Reinforced Concrete Design, CBS Publishers, 2013
2. Mallick S.K. & Gupta A.P., Reinforced Concrete, Oxford & IBH Publishing Co, 6e, 1996.
3. Pankaj Agarwal and Manish Shrikandhe, Earthquake Resistant Design of Structures, PHI, 2006
4. Punmia B. C., Jain A. K. Comprehensive Design of Steel Structures, Laxmi Publications (P) Ltd, 2017.
5. Ramchandra S & Veerendra Gehlot, Design of Steel Structures Vol. II, Standard Book House, 2007
6. S.K.Duggal., Design of steel Structures, Tata McGraw-Hill, 2014
7. Subramanian N, Design of steel Structures, Oxford University Press, 2015
8. Varghese P.C., Advanced Reinforced Concrete Design , PHI, 2005
9. William T Segui., Steel Design , Cenage Learning, 6e, 2017
10. IS 456 -2000 Code of practice for reinforced concrete design, BIS
11. IS 800 – 2007, Code of practice for Structural steel design, BIS

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks %
I	Design of Deep beams & Corbels. Design of Ribbed Slabs. Yield line theory of slabs – Design of Rectangular and Circular slabs for UDL and point load at centre.	6	15
II	Design of flat slabs by direct design method and equivalent	6	15

	frame method as per IS 456-2000. Design of multi-bay multi storied portal frames for gravity loads, Pattern loading - Use of SP 16 (Substitute Frame method of analysis may be followed).		
FIRST INTERNAL EXAMINATION			
III	Design of Light Gauge members - behavior of compression elements- effective width for load and deflection determination- behavior of stiffened and unstiffened elements- moment of resistance of flexural members- design of compression members	7	15
IV	Design of Gantry Girder :Introduction - Loading consideration & maximum load effect Selection of Gantry girder – Design of gantry girders for primary loads only. Codal provisions	7	15
SECOND INTERNAL EXAMINATION			
V	Design of Industrial structures : Introduction – Classification of Industrial structures- load estimation and steps for Analysis and design. Beam column connections (Unstiffened and stiffened)	8	20
VI	Tall Buildings –Introduction, Structural Systems, Principles of design and detailing of Shear wall. Design of Multistoried framed structures for wind and Earthquake Loads- Equivalent static load method of IS 1893.Ductility detailing for earthquake forces- IS 13920	8	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (End semester examination)

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE473	ADVANCED COMPUTATIONAL TECHNIQUES AND OPTIMIZATION	3-0-0-3	2016

Prerequisite : CE306 Computer Programming and Computational Techniques

Course objectives:

- To introduce different numerical solutions and importance of optimization
- To impart ability to apply mathematics and optimizing techniques for finding solutions to real time problems.

Syllabus :

Introduction to numerical methods- errors in numerical methods-Systems of linear algebraic equations- Elimination and factorization methods- Gauss Seidel iteration. Eigen Value problems- power method. General Optimisation procedures - and features of mathematical programming as applicable to Civil engineering problems. Unconstrained and constrained optimization problems - Formulation of objective function and constraints. Lagrangian interpolation- Quadratic and Cubic splines (Problems on quadratic splines only)- Data smoothing by least squares criterion- Non-polynomial models like exponential model and power equation- Multiple linear regression. Numerical integration- Newton – Cotes open quadrature- Linear Programming - Simplex method standard form - Simplex algorithm - Two phase solution by simplex method - Duality of linear programming Formulation of geometric programming. Ordinary differential equations- 1st order equations- Solution by use of Taylor series- Runge- kutta method- Ordinary differential equations of the boundary value type- Finite difference solution- Partial differential equations in two dimensions- Parabolic equations- Explicit finite difference method- Crank-Nicholson implicit method- Ellipse equations Non- Linear Programming problems – one dimensional minimisation. Unconstrained optimization Techniques Direct search method. Random search Univariate pattern search. Descent methods.

Course Outcomes:

The students will be able to:

i. Find different numerical solutions of complicated problems
ii. Determine solutions of real time problems applying numerical methods in mathematics
iii. Understand the importance of optimization and apply optimization techniques in real time problems

Text Books / References:

1. Grewal B.S. “Numerical Methods in Engineering and Science” Khanna Publishers.
2. Chapra S.C. and Canale R.P. “Numerical Methods for Engineers” Mc Graw Hill 2006.
3. Smith G.D. “Numerical solutions for Differential Equations” Mc Graw Hill
4. Ketter and Prawel “Modern Methods for Engineering Computations” Mc Graw Hill
5. Rajasekharan S. “Numerical Methods in Science and Engineering”S Chand & company 2003.
6. Rajasekharan S. “Numerical Methods for Initial and Boundary value problems,” Khanna publishers 1989.
7. Terrence .J.Akai “Applied Numerical Methods for Engineers”, Wiley publishers 1994.
8. R.L. Fox , Optimisation methods in Engineering Design, Addison Wesely
9. S.S. Rao , Optimisation Theory and applications , ,Wiley Eastern.
10. Belegundu., Optimisation concepts and Applications Engineering,

11. Andrew B Templeman, Civil Engineering Systems

COURSE PLAN			
Module	**Contents**	**Hours**	**Sem. Exam Marks %**
I	Introduction to numerical methods- errors in numerical methods- Systems of linear algebraic equations- Elimination and factorization methods- Gauss Seidel iteration. Eigen Value problems- power method.	7	15
II	General Optimisation procedures - and features of mathematical programming as applicable to Civil engineering problems. Unconstrained and constrained optimization problems - Formulation of objective function and constraints.	6	15
FIRST INTERNAL EXAMINATION			
III	Lagrangian interpolation- Quadratic and Cubic splines (Problems on quadratic splines only)- Data smoothing by least squares criterion- Non- polynomial models like exponential model and power equation- Multiple linear regression. Numerical integration- Newton – Cotes open quadrature	7	15
IV	Linear Programming - Simplex method standard form - Simplex algorithm - Two phase solution by simplex method - Duality of linear programming Formulation of geometric programming	6	15
SECOND INTERNAL EXAMINATION			
V	Ordinary differential equations- 1st order equations- Solution by use of Taylor series- Runge- kutta method- Ordinary differential equations of the boundary value type- Finite difference solution- Partial differential equations in two dimensions- Parabolic equations- Explicit finite difference method- Crank-Nicholson implicit method- Ellipse equations	7	20
VI	Non- Linear Programming problems – one dimensional minimisation. Unconstrained optimization Techniques Direct search method. Random search Univariate pattern search. Descent methods	7	20
END SEMESTER EXAMINATION			

QUESTION PAPER PATTERN (External Evaluation) :

Maximum Marks :100 **Exam Duration: 3 Hrs**

Part A -Module I & II : 2 questions out of 3 questions carrying 15 marks each

Part B - Module III & IV: 2 questions out of 3 questions carrying 15 marks each

Part C - Module V & VI : 2 questions out of 3 questions carrying 20 marks each

Note : 1.Each part should have at least one question from each module

2.Each question can have a maximum of 4 subdivisions (a, b, c, d)

Course code	Course Name	L-T-P - Credits	Year of Introduction
**451	Seminar and Project Preliminary	0-1-4-2	2016
Prerequisite : Nil			

Course Objectives

- To develop skills in doing literature survey, technical presentation and report preparation.
- To enable project identification and execution of preliminary works on final semester project

Course Plan

Seminar: Each student shall identify a topic of current relevance in his/her branch of engineering, get approval of faculty concerned, collect sufficient literature on the topic, study it thoroughly, prepare own report and present in the class.

Project preliminary:

Identify suitable project relevant to the branch of study. Form project team (not exceeding four students). The students can do the project individually also. Identify a project supervisor. Present the project proposal before the assessment board (excluding the external expert) and get it approved by the board.

The preliminary work to be completed: (1) Literature survey (2) Formulation of objectives (3) Formulation of hypothesis/design/methodology (4) Formulation of work plan (5) Seeking funds (6) Preparation of preliminary report

Note: The same project should be continued in the eighth semester by the same project team.

Expected outcome.

The students will be able to

i. Analyse a current topic of professional interest and present it before an audience
ii. Identify an engineering problem, analyse it and propose a work plan to solve it.

Evaluation

Seminar : **50 marks**

(Distribution of marks for the seminar is as follows: i. Presentation : 40% ii. Ability to answer questions : 30% & iii. Report : 30%)

Project preliminary : **50 marks**(Progress evaluation by the supervisor : 40% and progress evaluation by the assessment board excluding external expert : 60%. Two progress evaluations, mid semester and end semester, are mandatory.)

Note: All evaluations are mandatory for course completion and for awarding the final grade.

Course Code	Course Name	L-T-P-Credits	Year of Introduction
CE431	ENVIRONMENTAL ENGINEERING LAB	0-0-3-1	2016

Prerequisites: CE405 Environmental Engineering - I

Course objectives:

- To equip the students in doing analysis of water and wastewater samples

List of Experiments: (Minimu 10 experiments are mandatory)

1. To analyse the physical characteristics viz. colour, turbidity, and conductivity of a given water sample and to determine its suitability for drinking purposes
2. To analyse the chemical characteristics of a given water sample viz. pH, acidity, alkalinity for assessing its potability
3. To analyse the chemical characteristics of a given water sample viz. chlorides and sulphates content to assess its suitability for drinking purposes and building construction
4. To determine the Dissolved Oxygen content of a given water sample for checking its potability
5. To determine the available chlorine in a sample of bleaching powder
6. To analyse the various types of solids in a given water sample
7. To determine the BOD of a given wastewater sample
8. To determine the COD of a given wastewater sample
9. To determine the optimum dosage of alum using Jar test
10. To determine the Nitrates / Phosphates in a water sample
11. To determine the iron content of a water sample
12. To determine the MPN content in a water sample and assess the suitability for potability

Expected outcome:

- The students will be able to assess quality of water for various purposes